**FINAL REPORT**

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**Title:** Development of a Landscape Irrigation Runoff Mitigation System

**Priority Area:**
Urban/municipal landscape water conservation

**Project Summary:**
Urban/municipal water use continues to represent a significant portion of overall water demand in Texas, and given the rapid pace of urban growth in the state, the sector will likely see even greater increases throughout the coming decades. Outdoor water use accounts for almost 1/3 of annual residential water use in Texas, with studies showing that homeowners often overwater landscapes by as much as 2 to 3 times the amount needed. Water conservation has been a major focus of extension outreach programs, municipalities, and water management districts within Texas, yet adoption of these programs has been challenging, especially in relation to proper lawn/landscape irrigation practices. One needs simply to drive through a suburban residential neighborhood in the early morning to observe the inefficiency at which irrigation water is used. Irrigation runoff from lawns into adjacent streets and storm sewers has been a seemingly impossible problem to solve for decades, and has been compounded by day-of-the-week irrigation restrictions common to most major communities across the southwest. In addition to irrigation runoff being a wasteful use of water resources, it is also well documented that lawn runoff can be a source of nutrients, pesticides, and dissolved organic carbon moving into nearby surface waters. For this reason, many communities have enacted watering ordinances prohibiting wasted irrigation water due to runoff flowing away from irrigated areas. EPA regulations also now prohibit off-site movement of effluent irrigation onto adjacent properties.

In light of this challenge, our team has worked to develop a ‘Landscape Irrigation Runoff Mitigation System’ (LIRMS) for mitigating irrigation runoff losses from residential or commercial landscapes in situations where automatic irrigation systems are used; primarily where landscapes adjoin paved streets draining to storm water sewer systems. Low-cost, yet durable flow sensors have been designed for use in the system, capable of detecting very low flow volumes when runoff begins. If runoff is detected above a defined threshold, the flow sensor communicates back to the irrigation system controller, which is paused for a given period of time (length of shut off time is currently manually programmed, but could be refined through additional research to compensate for factors including time of day, soil texture/infiltration rate,
soil moisture, slope, etc.) before resuming the irrigation cycle. Upon resuming the cycle, if runoff flow is again sensed, the system again is paused (Figure 1 below).

The system effectively overrides a scheduled irrigation program, and leads to an automated 'cycle-soaking' of irrigation until the programmed run time has been satisfied (currently, most residential controller systems are limited to only 1 to 3 manual start times in terms of their cycle-soaking capacity) or until a pre-programmed window of time has expired. Our system is currently compatible for use with both soil moisture and ET-based irrigation scheduling systems, and can also eliminate need for a rain-sensor. Furthermore, because the system is programmable, it has the potential to control the irrigation system autonomously through direct control of valves without the need for existing irrigation controllers.

In a series of recent tests comparing LIRMS controlled irrigation vs. industry standard irrigation practice at our runoff measurement facility, LIRMS was able to reduce landscape runoff by up to 50% during a typical 1” irrigation event, with industry standard irrigation heads delivering precipitation rates of 1.5” per hour. Note in the figure to the right, while a noticeable flux of irrigation runoff (approaching a rate of 0.25 L/sec) occurs under the industry standard irrigation early into the cycle, LIRMS quickly detects and responds to the early stages of this runoff, pausing irrigation, and cycle soaking it through the duration of the allotted run period, thus mitigating significant runoff fluxes for the duration of the 4-hour run window. Also important to note is that runoff flow rates from the LIRMS plot do not exceed 0.02 L/sec at any point during the 4 hour period (Figure 2). As these data clearly illustrate, we have demonstrated not only functionality of the system, but also significant

Figure 1. Operation profile for control plot programmed for a 30-minute irrigation cycle (upper left) and LIRMS-controlled irrigation in which irrigation is repeatedly paused/resumed in response to detection of runoff (upper right).

Figure 2. Runoff flow characteristics of a standard single 30-minute irrigation event (hollow circles) or LIRMS controlled irrigation (solid circles) where irrigation is repeatedly paused and continued in response to runoff.
potential of the system to reduce runoff losses and improve irrigation efficiency in the landscape. Because of this, a provisional patent ‘Method and System for Reduction of Irrigation Runoff’ has been filed for the system. At the same time, the team has identified areas for future research efforts which should result in greater ease of operation and higher system efficiency.

**Approach:**
During the first phase of the project, four types of irrigation runoff sensors, based on different working principles were designed and manufactured in the laboratory. Various housings were designed and evaluated, all of which needed to fit into a 6” x 6” space for accommodating curb installation. Next, a central control unit which is capable of receiving signals from sensors and controlling several irrigation valves at the same time was designed.

The next phase of the project consisted of installing all the prototypes into simulated lawn/curb plots in the field (Figure 3a) and hardwiring them with the central control unit (Figure 3b). Four different types of prototypes were used and compared to determine which ones perform the best. Irrigation tests were run, with the operation and amount of runoff from each prototype recorded and used as index of performance. The units offering the best performance both in terms of sensitivity, runoff reduction capability, and reliable field operation under typical lawn maintenance conditions were advanced for field testing.

Next, wireless communication between the irrigation runoff sensors and the central control unit was established, which made the system more autonomous in terms of connectivity. The quality of the wireless communication and corresponding performance of the new wireless irrigation runoff sensor systems were evaluated. Due to interference issues resulting from simultaneous wireless communication of 8 adjacent zones and the central controller, the decision was made to work with hard-wired systems for the purposes of demonstrating proof of concept and field performance.

An autonomous energy system was also explored combining solar panels and rechargeable batteries. The solar panels provided energy for the sensor and for recharging the batteries during daytime so the system could work in the evening or early morning hours. The performance of the autonomous energy system was tested. Lastly, the LIRMS was coupled with the irrigation controller using a software-based algorithm. Field tests were conducted with data manually downloaded from the control unit to validate the performance of the LIRMS concept as well as to begin to characterize operation and performance of the system. These tests also allowed the team to identify points of inefficiency that could be addressed in future testing efforts aimed at improving the system. The technology has been validated and it is ready for deployment beyond the lab. Municipal water districts in both College Station and San Antonio have been contacted.
and have expressed great interest in partnering to collectively explore how this technology could be best implemented to benefit citizens while helping to achieve municipal landscape water conservation goals.

**Goals and Outcomes Achieved:**
The objective of the study was to design a reliable, durable, and low-cost Landscape Irrigation Runoff Mitigation System (LIRMS) that could function to minimize irrigation runoff losses from residential or commercial landscapes. A reliable and inexpensive irrigation runoff sensor was designed and tested with an irrigation controller module. During the field tests, the designed LIRMS has shown the capability of reducing runoff by 40 to 50%, while also allowing from 10 to 30% more water to be absorbed by the soil during a typical 1” irrigation event. Because lawn runoff is a source of fertilizer, pesticides, and bacteria eventually making its way into surface waters, the system may positively impact environmental quality in ways beyond direct water conservation. The potential applications and marketability of the system are enhanced due to the fact that it can also be either used as an add-on technology to an existing irrigation controller or as an independent, stand-alone controller.

**Beneficiaries of the Research:**
Some potential beneficiaries of the research could include 1) home and business owners (due to greater irrigation efficiency and thus, less need for irrigation), 2) municipalities and water districts (the system can affect reduced water consumption and lower peak demands on water supplies during allowable irrigation days, 3) all citizens in states where water conservation is a high priority (reduced landscape potable water use = more available water for human consumption), and 4) the environment (greater irrigation application efficiency reduces runoff and thus reduced nutrient, pesticide, and bacterial loading of surface waters).

**Lessons Learned/Impacts:**
- Field conditions are different from the lab, which led to various challenges such as corrosion, and clogging of the devices. As a result, the devices had to be redesigned to avoid the long-term effects of field conditions on them.
- It was realized that water chemistry (rainfall vs. irrigation) affected performance of those prototypes relying on electrical conductance for operation, however, use of alternative technologies in the system allowed us to overcome this issue.
- The current LIRMS functions best as a hard-wired system. Early attempts to create a wireless LIRMS led to interference problems from adjacent devices in nearby zones.
- The current LIRMS system will continue to attempt to apply irrigation until the scheduled irrigation runtime has been satisfied, or until the operation window has expired. Thus, our future efforts will seek to improve efficiency of the system in terms of recognize appropriate lengths of pause periods based on ambient soil moisture, soil texture, slope, etc., or to simply recognize when soil saturation has been achieved based on the runoff dynamics.
- Despite some of the unanticipated issues encountered, the team is highly optimistic about the results of the project. Based on this 2-years of testing, the system shows the potential to perform as conceptualized, resulting in significantly reduced runoff and offering improved irrigation application efficiency to the landscape.
- We believe additional field testing would help to 1) refine and improve the operation of the system to allow for wireless operation/data acquisition/troubleshooting as well as determining how to best program LIRMS for diverse soil conditions and landscape sizes and 2) help to provide a larger body of data to support potential runoff savings from the system. These efforts would help to improve the marketability of the system to residential/commercial irrigation companies and/or municipalities.

**Intellectual Property:** A provisional patent has been filed. Additional IP protection is being sought including the filing of a full utility patent for the LIRMS system.

**Source and Amount of Funds Leveraged:**
We utilized selected plots from our recently constructed $250,000 urban turf runoff facility for field testing of prototypes. This facility was supported in large part through financial support from the Scotts-Miracle Gro Company and Toro Irrigation.

**Publications/Presentations Generated***:


*Additional publications currently being withheld due to pending patent application.*